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THE COMPUTER AND SMALL BUSINESS

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Rex G. Hamaker

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by

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Lieutenant, United States Navy

Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE
IN
MANAGEMENT

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This work is accepted as fulfilling
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MASTER OF SCIENCE
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ABSTRACT

The place of the computer in small business is investigated with respect to what type of problems it can solve for small business and how the small firm can acquire time on one. The decision-making process and the importance of information is discussed in relation to small business. Several applications of computers are examined to show how the firm can use the computer in day-to-day business operations. The capabilities of a digital computer are discussed and some of its characteristics are compared to the human brain. Three methods of acquiring use of a computer are investigated and compared. The objective of this analysis is a better understanding of the computer's place in small business.

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I

INTRODUCTION

Can today's small businessman use the modern computers and computer techniques in his day-to-day operations? If so, how can he gain access to a computer? These two questions are of major importance to the small manufacturer, merchandiser, or supplier of some type of service. In almost all areas of business, a computer can be helpful in decision-making, inventory control, manufacturing processes, and in many other varied types of business activities. In the past twenty years, the computer industry has grown from an idea to a major segment of the nation's productive effort. This expanding industry grew mainly due to the government's and large businesses' demand for bigger, and as a result more complicated, calculating and accounting devices. As these pieces of equipment evolved, they grew larger and larger, and more and more expensive. Up until the past few years the small businessman couldn't afford to purchase or even rent a computer, nor did he have any real idea of what to do with one if he had it.

This paper investigates the two basic questions: How can a computer be used by small business? And, how can a small business gain access to one? It delves into some of the areas which are common to many small businesses where a computer can make a definite contribution to the firm. It

examines the possible methods a small business can use to avail itself of a computer. The objective of this investigation is to determine the role of the computer in the small business as to what the computer can do for the small firm and its means of utilizing a computer.

Chapter II is a short background into the thinking of small companies concerning computers, their evolution, and some basic definitions. This chapter also includes a short resume' on decisions and the decision-making process.

Chapter III presents some of the typical areas in which a computer can be used to assist the small business firm.

Chapter IV presents some of the characteristics of the digital computer and an analogy between the digital computer and the brain.

Chapter V presents the three methods by which a small business can acquire the use of a computer -- computer service firm, time-sharing system, purchase of a small computer -- and makes a case for the use of each. This chapter will compare the advantages and disadvantages of the three methods presented.

Finally, Chapter VI will draw some conclusions concerning the material presented.

II

BACKGROUND

About twenty years ago the automatic computers arrived on the scene for the first time. Its evolution has been directed mainly by an academic group of designers, engineers, programmers, and mathematicians whose efforts have been concentrated on computers' incorporating higher speeds, larger memory capacities, and more extensive input/output peripheral equipment. This burgeoning development, although vitally needed, has produced more and more sophisticated and expensive equipment. Only large corporations can afford to purchase a computer installation costing two million or more dollars. Even those corporations that can afford the large computers must keep such expensive equipment busy, usually sixteen hours a day at least, in order to pay off the initial heavy investment within a reasonable time.[1]

But what about the small businessman? He needs a computer's help scarcely once a week. Can he take advantage of the time-saving, labor-saving electronic computer to strengthen his competitive position?

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[1] Seligsohn, I. J. "Using Computer Services In Small Business," Computers and Automation, 9:15, May 1960.

For a number of years, many small companies felt that automatic data processing was just one of the many factors making life easier for the big firm and harder for the small. Lately, however, there has been an awakening of interest by small business in computers and how the computer can assist small businesses in their day-to-day operations. Several developments in the computer industry have caused this awakening. The first is that the computer manufacturers have begun to develop smaller machines in the price range of $5,000 to $10,000.[2] The other development is an increasing interest by the computer industry in the computer service bureau concept. There has also been a good deal of investigation into time-sharing systems. Progress in this area was limited, though, until 1961 when it was thoroughly investigated and found that a type of time-sharing system was feasible.

For this research paper some basic definitions are necessary.

1. Computer -- a machine which is able to calculate or compute, that is, which will perform sequences of reasonable operations with information; mainly logical and arithmetic operations.[3]

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[2] Diebold, John "Experience, 1959, in Automatic Data Processing," Computers and Automation, 9:11, July 1960.

[3] Berkely, Edmund "Glossary of Terms in Computers and Data Processing, Computers and Automation, 5:12, July 1960.

2. Small business -- a business which usually falls into one or more of the following categories: is independently owned, employs fewer than one hundred people, and is worth less than one million dollars.[4]

3. Program -- a set of coded instructions in a language which can be understood by the computer (FORTRAN, COBOL, ALGOL).

4. Time-sharing system -- a computer system similar to a public utility system, described as the simultaneous use or sharing of a computer by a number of users, common carrier computers.

How accurate are the results of any computerized calculations or information? It is important to understand that a computer has no imagination and cannot "think" for itself. It only follows what it is told to do. If the problem the computer is to solve is well structured and the data fed into the computer are fairly accurate, then the results will reflect the accuracy of the input data and program. If the problem is poorly structured and the inputs are just gross estimates, the outputs will be just estimates, i.e., in colloquial slang "garbage in -- garbage out". The reason for existence of the computer is its fantastically fast computational speeds and its large data storage capacity. The outputs

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[4] Nanassy, Louis and William Selden. Business Dictionary. Newark: Prentice-Hall, 1960, p. 190.

from the computer can be in several different forms, i.e., customer billing, presentation of alternatives for decision-making, etc.

There are two main goals which are common to all businesses large or small: to remain solvent and to earn a profit for the owners or stockholders. The only way for businesses to achieve these goals is for the manager or executives of the firm to make the correct decisions at the right times. Since proper decision-making is one of the prime reasons for continued existence of businesses, it is necessary to examine the definition of "decision-making". The word decision has been defined as a choice among a group of alternatives.

Decision-making is generally considered to be a three-step process. The first step involves the assessment of the problem. The second step involves a listing of all the alternatives. Since there are normally many ways of accomplishing a desired result, this step, in essence, catalogs all the possibilities and, if necessary, weighs them either empirically or by intuition in preparation for the third step. Step three in this definition of the decision-making process is deciding among the alternatives developed in step two.

Using the definition that a decision involves a choice from a group of alternatives, two kinds of decisions suggest themselves. In computer language, they can be thought of as

programmed decisions and non-programmed decisions.[5] Programmed decisions are routine and repetitive such as reorder points in a stock control system and payroll preparation in a large company. More difficult programmed decisions where the rules are more complicated, but nonetheless defined, would be process control systems and automated assembly lines. In the non-programmed area, such decisions are how to merchandise a special product or make a fundamental change in the firm's financial structure. Appendix I describes in greater detail the hierarchies of the programmed and non-programmed decision making techniques.

Information is the basis upon which all decisions are made. The quality of both information and the processing of it is a critical factor in determining the quality of the decisions. Quality of information is determined by such factors are relevance, precision, completeness, and timeliness. The quality of information processing is affected by such factors as speed, accuracy, ability to handle complex relationships, and flexibility.

It has been necessary to examine the decision-making process to aid in determining how a computer can be used in a small firm. This having been done, an investigation into several representative types of problems, which face the small business, may now proceed.

[5] Simon, Herbert. The New Science of Management Decision. New York: Harper and Row, 1960, p. 5.

III

AREAS OF APPLICATION

With the use of a digital computer, the small business firm can now solve a wide range of business problems -- the solution of which will enable the firm to become more efficient and therefore, more competitive in the market. Some representative areas in which a computer can be of great assistance are in the fields of engineering, financial and clerical data reduction, transportation and distribution, and management analysis.

Engineering Problems

Complex engineering problems often must be solved before a given product can be manufactured. Typical of these that can best be solved by a computer include vibration analysis, heat and pressure calculations, stress analysis, engine and lens design.[6] One type of ancillary output equipment now being produced by several computer manufacturers is known as the light pen and scope display, or Computer Aided Design.[7] With this equipment, an engineer first sketches the design for a part on the face of the tube with the light pen or scope, then in accordance with a program which is stored in the computer,

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[6] Grabbe, Eugene (ed.). Automation in Business and Industry. New York: John Wiley and Sons, 1957, p. 214.

[7] Grabbe, Eugene M. (ed.). Automation in Business and Industry. New York: John Wiley and Son, 1957, p. 192.

the computer straightens up the lines and makes the drawing to the desired size. Specifications for standard subassemblies, such as bearings, can be stored in the computer and added to the drawing. The engineer can copy the completed design directly from the scope display to his drawing. The engineer can then simulate a test on the part by indicating direction, position, and magnitude of the loads the part is being designed to withstand. The computer will calculate the effects of these loads on the part and will display the information as to whether the part will withstand, deform, or fail under such a test. With this type of equipment, the small manufacturer can do major design work without the cost of destructive testing of the finished product. With the time reduction realized by the use of the computer in these lengthy and complicated problems, small manufacturers can now enter new fields that were closed to them before the advent of the computer.

Financial and Clerical Problems

The high speeds of electronic digital computers make possible rapid processing of a great amount of clerical data.[8] Computers can drastically cut the time and costs spent on functions such as payroll processing, billing, shop order writing, and sales analysis. Several small firms have found that fewer clerks can handle much more work in less time and at a lower ultimate cost with the aid of the computer.

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[8] Hein, Leonard. Electronic Data Processing For Business. Trenton: D. Van Nostrand Company, 1961, p. 103.

The computer can also help provide small firms quickly with up-to-date control information for use in inventory control and cost accounting. Fundamentally, there are two basic approaches to inventory control; the fixed order quantity system and the period review system.[9] In the fixed order quantity system, the number of units to be ordered each time and the stock level, which triggers the replenishment order, are fixed by management. Given these two basic parameters, the system is then allowed to operate on a routine basis and only interrupted when significant changes in demand or product take place. The determination of the number of units to be ordered each time follows standard economic order quantity formulas. The determination of when to place a replenishment order involves a more complex set of factors involving probability concepts. The factors have to do with the probability of a heavy demand during a particular period, of a light or even no demand, and of having a "stockout". In the periodic review system, a fixed time interval between stock reviews is specified. At each review an order will vary from one review to the next, depending upon demand fluctuations. In both of these inventory control systems, the computer can provide up-to-date information to the firm.

[9] Stockton, Robert. Basic Inventory Systems. Boston: Allyn and Bacon, 1965, p. 7.

The freshness of this information is vital to the success of a business. A small manufacturer can, with the use of the computer, receive a complete sales and inventory analysis once a week or even once a day if the volume is high. This will assist him in balancing out his operations thus preventing over or under-production and keeping his inventory low without the risk of running short. For highly seasonal products, computers can predict within reasonably safe limits, the requirements for preseason, post-season, and working inventories of finished items and sub-assemblies. This helps level out production cycles, lower costs, and obtain more efficient operation. Before computers were available, the small manufacturer would have to make his production decisions using information which was months old, and then his plans were based on out-of-date estimates rather than on up-to-date information.

The determination of whether a firm is earning a profit, or operating at a loss, is made by the use of an accounting system. No matter how large the firm is, it must have some type of accounting system. Accounting systems cover the entire span, from the pencil and scratch paper used by the fruit stand operator to a complex cost accounting and financial reporting system used by very large corporations and the government.

A cost accounting system has three major objectives: (1) to accumulate costs necessary for the preparation of general financial statements, (2) to provide levels of management with cost data necessary for the control of costs, (3) to provide management with cost information necessary for business decisions.[10] Small firms can use a cost accounting system in their day-to-day business very effectively. Considering that the three objectives of a cost accounting system are the actual outputs of the system, some examples can be shown as to how small business can use the system. The accurate preparation of financial statements is necessary to determine the profitability of the firm and also for submission to lending institutions if the firm wishes to borrow money. Even though the vast majority of small business firms have only one level of management, that being the owner, it is important for him to have accurate accounting data on each of his cost centers to be able to control costs in these areas. Almost every business decision a firm makes will affect its operating costs. For these decisions to be correct, they must be made on accurate cost data.

A corollary to cost accounting is a system of cost analysis. Some of the analysis involves determination of: direct and indirect manufacturing costs, direct and indirect distribution costs, break-even points, cost-profit-volume relationships,

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[10] Crowningfhield, Gerald. Cost Accounting: Principles and Managerial Applications. Boston: Houghton Mifflin Company, 1962, p. 6.

profit and loss, and decision-making costs. All of these procedures and tools can and should be used by a firm, no matter what its size, in order to determine its overall efficiency.

Many other types of business need up-to-date information; for instance, wholesalers, manufacturers' agents, construction firms, brokerage houses, and small banks. Customer accounts of all of these businesses can be handled with equal facility by computers.

As can be seen, the computer, with its ability of fast mass data reduction and storage, can perform a definite service to the small firm which seldom has the clerical capacity and technical know-how to handle the more advanced inventory and accounting systems.

Production Problems

Small manufacturers have been making increasing use of the computer to solve complex production problems such as:

1. Machine shop scheduling -- finding the number of each item to be produced by each station in the machine shop, to minimize delays and overtime, and to shorten delivery time.

2. Production scheduling -- designing schedules to meet expected sales, and varying these schedules in accordance with sales fluctuations.

3. Blending or mixing problems -- finding the best combinations of raw materials or ingredients.

4. Reduction of trim losses -- forming, shearing, slitting, or punching rolls and sheets of material to produce various sizes, while at the same time minimizing waste.

The typical small manufacturer seldom has the knowledge or staff to calculate mathematically the most precise solution to such problems. Until recently, the best he could do was make an educated guess as to how he should operate his production lines or machines. But now, through the use of a high speed computer, he can come up with the answer which will yield the most profit after examining all of the factors and exploring some of the possible choices.

Transportation and Distribution Problems

Illustrative of these problems would be a business which operates a fleet of trucks. In this case, the trucker would want to find the most economical routes to follow considering mileages, traffic congestion, toll roads, and load capacities. Another example would be the small manufacturer who has to insure that his product is stocked in the proper amount at the most optimal distribution points.

Management Analysis Problems

The computer can also aid the small businessman in the field of management analysis and prediction. They can provide the necessary information or alternatives when the firm is:

1. Deciding where to locate a new plant or branch, taking into consideration the expected customer demand, transportation, distribution and many other factors which affect costs and profits.

2. Deciding whether to make or buy components -- which items or parts to manufacture, which to buy, and when.

3. Evaluating bids -- deciding which offering is most desirable when prices, terms, and conditions vary among the bidders.

4. Forecasting sales and demand -- performing market research by determining sales probabilities in different geographical areas for different products.

Operations Research

Many of the techniques used to solve these problems have been developed in the field of operations research which applies the methods of science to the operating problems of the business. These analytic techniques for information processing were developed from original studies made of some weapons and systems during World War II. The approaches devised then and improved upon in the following years have become the tools and techniques used by operations research (OR) people in assisting the manager or firm in making decisions among alternative courses of action. Some of these techniques are as follows:

1. Probability Theory and Statistics. The techniques of classical or Bayesian statistics are essential to almost all

practical OR problems. It is usually necessary to determine the probability distribution for one or more of the parameters of any realistic business problem. It is often necessary to use statistical techniques to evaluate the effect of variations in the input parameters for many types of OR problems. Statistical decision theory can be used for solving most of the problems which attempt to maximize expected profits or minimize expected losses. The solutions obtained from statistical techniques are not analytic but are approximations to optimum solutions in the long run. The techniques are limited to parameters which have known distributions and can usually be handled by using Monte Carlo techniques and simulation.

2. Linear Programming. Linear programming involves the use of mathematical equations for obtaining theoretically the best solution for problems of allocation of scarce resources among competing uses.[11] Linear programming theory has been used in many industrial applications such as: transportation scheduling, warehouse planning, production scheduling, inventory control, blending of fuels, mixing feed for cattle, personnel assignment, and plant layout. These techniques have been expanded to include non-linear programming, integer programming, and quadratic programming.

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[11] Dunlop, John (ed.). Automation and Technological Change. Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1962, p. 71.

3. Dynamic Programming. The theory of dynamic programming was developed to handle OR problems involving (1) multistage processes, (2) large numbers of variables, (3) chance events, and (4) the determination of policies rather than functions. This technique provides a theoretical framework for handling some of the more complex OR problems which cannot be solved with some of the other techniques. It is a general technique which can be applied to many of the basic OR analytic "models." Dynamic programming is a mathematical formulation which can be applied to the problems of economic administration of continuous interrelated processes, such as in production scheduling through sequential departments.[12]

4. Heuristic Programming. The major aim of heuristic programming is to prepare computer programs which can solve problems that before have required intelligence. Heuristic programs have been written for balancing assembly lines, scheduling in job-shop manufacturing, and selecting stock portfolios. Heuristic techniques have been applied to these problems because the mathematical solutions are too complex or require too many computations.[13]

5. Game Theory. Game theory is the mathematical analysis of games and their principles, taking in the considerations of strategy and counter-strategy among competitors, to

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[12] Ibid.

[13] Ibid.

find the best strategy against an opponent's actions.[14] Such analyses have been used in marketing operations where brand, price, and comparable decisions should be made only after consideration of the actions open to competitors.

6. PERT. PERT, which is the acronym for Program Evaluation and Review Technique, is an application of linear graph theory to the solving of sequencing problems. It is a technique which can be used to determine the time required to complete phases or operations within a project or process. It is also used to determine the total normal time required to complete the entire project as well as the shortest time necessary to complete the project. There are several types of PERT systems: PERT cost and PERT time.

7. Simulation. Most OR specialists resort to the simulation technique only when they cannot obtain an analytic solution to a problem. Simulation will not provide a precise solution to a problem, but it will usually provide a good numerical approximation to the solution in a reasonable time. It is also possible to combine mathematical analysis and simulation to reduce the time required to obtain a satisfactory solution. Simulation is based on the use of random numbers to approximate random times at which a series of events might occur. Many real problems can be solved with a pencil and a table of random numbers, but most realistic business problems require

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[14] *Ibid.*

the use of a computer. A well designed simulation problem for a computer will not only provide the solution to the problem, but will also provide an output which is meaningful to management.

8. Economic Theory. Although economic theory is seldom listed as a technique of operations research, it is obvious that at least a minimum amount of economic theory must be involved in any business problem, especially if the aim is to obtain a solution which maximizes some economic parameter.

All of the techniques and tools listed can be programmed for the computer which will put out a feasible solution to the the problem or alternatives from which the firm can decide as to what action to take. The output of a computer is only as good as the information fed into it. If the inputs are gross approximations, the outputs will probably be the same.

Even though many of these tools and techniques are too sophisticated for the average small businessman to use, with a small amount of self-education he can apply several of these techniques to his business such as probability theory and simulation. Now that it has been shown in what operating areas of a business the use of the computer can be of a definite assistance, a short description of how a computer operates and its abilities is now necessary.

IV

THE COMPUTER

During the last twenty years, industry has witnessed the introduction of many types of electronic computers. The first computers were designed for solving scientific and engineering problems, but many types of computers have since found widespread use in business data processing as well as production process control. For complex problems, computing facilities are almost mandatory because of the time limits.

The introduction of computers opens up possibilities for significant savings for any organization, but a computer of almost any size involves large sums of money for planning and organization, not to mention the purchase costs or rental fee for the equipment. The computer is just a business machine and its cost must be less than the benefits it generates. The decision to utilize computers must ultimately rest on the factors of cost, speed, and the relative ability to solve problems.

Digital Computers

The digital computer is so named because it counts digits. The abacus is probably the simplest digital computer, the desk calculator and punched card accounting equipment are somewhat more advanced and the high-speed electronic digital computers are the most advanced. The electronic digital computer has been widely used for engineering and mathematical work requiring involved calculations; but in addition it is being used at an

increasing rate for accounting, payroll, inventory, and other data processing problems which are characterized by massive amounts of data.

The businessman should always keep in mind that although digital computers work at higher speeds, are more automatic, and are more complicated than other office machines, most of the operations performed by a computer can also be done by other equipment which any business already has available. It is fantastically fast computational speeds and large storage capacities that make their use desirable. Computers often have been called "giant brains." This is not true. In fact, computers are so lacking in imagination that every operation they perform, including even stopping and starting, must be preplanned by a human.

Programming

This preplanning for the computer is called programming. The computer must be told in detail, all the steps it must carry out to arrive at the desired solution. These steps are expressed as a sequence of simple arithmetic operations (add, subtract, divide, multiply, etc.) and logical comparisons (greater than equal to, less than). In many respects, a program is analogous to a railroad track and a train. Once the computer is started, it explicitly follows a pre-determined path (program) pausing at certain times to receive or discharge information, and deciding at other times which of possible different paths to take.

The programmer must be familiar with the route and know where the computer will stop and what types of decisions will have to be made.

Once a program has been developed, it is recorded on magnetic or paper tape. Then, when a similar problem arises, it is only necessary to use the new data and an existing program together with perhaps some new program to coordinate the two.

Computer Components

The components of any particular computer will depend on the types of problems it is designed to solve, and vice versa, the types of problems solved will in turn depend on the components of the computer. For example, scientific calculations require a relatively small quantity of input and output information, the input data are not changed by the computation process, and the time requirements usually are not too stringent. Data processing is characterized by large amounts of data that are subjected to relatively simple arithmetic operations and as a result large storage capacity is needed. Time requirements become critical because vital schedules must be met (such as payrolls) so that speed of input and output must be considered. Programming of a typical business system is quite complex because of the great number of non-structured decisions to be made.

Computer components carry out the five major operations

in a computer: (1) input, (2) control, (3) arithmetic, (4) output, and (5) memory. These components may or may not be housed in the same cabinet. The components work together in this manner: the program and data are prepared in advance for input on tapes or punched cards. This information is then fed through the input unit and stored in the memory section. The sequence of steps specified in the program is then carried out by the arithmetic unit, with all operations controlled by the control unit. Results of calculations are sent back to the memory. Occasionally it may be necessary to get additional data through the input unit or from the memory unit. When the final answers are determined, the output unit translates the information into readable output, the form of which depends on the eventual use of the results. A permanent output may be in the form of a printout on paper (for review by user), on punched cards (for further data processing), on paper tape (for control operations), or on magnetic tape (for storage).

Brain vs Computer

The high speed digital computer often has been thought of as a substitute for the human brain. Since the computer has no imagination, this concept is obviously wrong. It is interesting, though, to compare some of the characteristics which are common to both the brain and the computer. Table I represents

the characteristics of the human brain in language of neurophysiology.[15] Table II represents a group of computer characteristics in the language of the electrical engineer.[16] Table III compares the computer with the brain by translating the words used by the physiologist and the engineer into words the layman can understand. Needless to say, this analogy is not complete. The computer has no comparable processes to several of those which occur in the brain. There are other assumptions such as degree of retention of material in the human memory and those involving pulse rates, which have not as yet been proved and which would affect the comparisons greatly. One trait which stands out in this analysis is the fact that the human brain is far more compact than the computer. On the other hand, the machine has a great speed advantage over the human.

[15] Von Neumann, J. The Computer and the Brain. Hartford: Yale University Press, 1958, p. 44-49.

[16] Ibid.

TABLE I

Human Brain Characteristics*

Trans-Synoptic Stimulation and Fatigue Time	10^{-2}	sec.
Size of Membrane	10^{-5}	cc.
Volume of Brain	10^{-3}	cc.
Number of Neurons in Brain	10^{10}	
Volume-per-Neuron	$\frac{10^{3}}{10^{10}} = 10^{-7}$	
Dissipation per Cell (Neuron)	10^{-9}	watts
Memory Capacity by Age 60	10^{20}	bits

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*Reference: Von Neumann, J. The Computer and the Brain. Yale University Press, 1958, p. 44-49.

TABLE II

Medium Computer Characteristics*

Reaction Time	10^{-6}	sec.
Inter-Electrode Distance Transistors	10^{-2}	cm.
Volume	10^{6}	cc.
Core Storage Capacity	3×10^{4}	cells
Volume-to-Cell Ratio	$\frac{10^{6}}{3 \times 10^{4}} = .33 \times 10^{2}$	
Dissipation per Cell	10^{-1}	watts
Total Storage Capacity (with modular devices)	10^{9}	computer words

*Reference: Von Neumann, *op*. *cit*,: 47-49, combined with data representative of a medium-fast computer, e.g., CDC 1604.

TABLE III

Comparison of Brain with Computer*

Brain		Computer
10^{-2} sec.	Time required to act on an input command	10^{-6} sec.
10^{-5} cc.	Size of Action Surface	10^{-2} cc.
10^{3} cc.	Volume of Computing Medium	10^{6} cc.
10^{10} cells	Self-contained Storage Capacity of Conducting Medium	3×10^{4} cells
$\frac{10^{3}}{10^{10}} = 10^{-7}$	Volume to Storage Unit Ratio	$\frac{10^{6}}{3 \times 10^{4}} = .33 \times 10^{2}$
10^{-9} watts	Dissipation per self-contained Storage Capacity	10^{-1} watts
10^{20} bits	Maximum Total Usable Storage Capacity	10^{10} bits

*NOTE: Information in this table is a combination of Tables I and II. The bridge words are the author's interpretation of Von Neumann's notations.

V

METHODS OF ACQUIRING COMPUTER TIME

In order to determine a method by which a small firm can acquire the use of a computer, the firm must first investigate all of the alternative methods available to it. Even though there may be quite a few methods that can be used, only three will be explained and compared. These three being -- hiring of a computer service firm, use of a time-sharing computer system, and purchase of a small computer. These three are presently in use by many large firms and are available to small businesses at a relatively low cost. These three methods are presented on a case basis with an explanation of each.

Computer Service Organizations

In almost every major city and industrial complex, there is a computer service organization. These firms may be a division of some computer manufacturer or a small business itself.

Some of these computer service firms have complete staffs of mathematicians, economists, and other professional personnel in addition to their computer specialists.[17] One or more of these people can come into a small firm or plant, analyze the problem, and gather the pertinent data necessary to solve it.

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[17] Seligsohn, op. cit.: pp. 14-16.

Computer service experts are used only as consultants and not as regular staff or operating personnel.

Typically, a computer service firm has at least one large general purpose digital computer on its premises. The general purpose nature of the digital computers implies that many different businesses can provide the information to solve many different kinds of problems on these machines, and this is exactly what happens. The computers, therefore, are used very extensively by these service organizations which have a variety of clients, many of them small, in nearly every field of business and industry.

There are two types of service which a computer service firm offers: programming and computing machine services. In programming services, a computer analyst first carefully studies the problem and states whether or not a computer solution is feasible and economical. He helps in determining whether the problem is complex or difficult enough to warrant a computer solution. When the analyst is finished, he turns the problem over to the computer programmers. The service firm is paid for only the programming services for that particular problem. This alleviates the overhead cost to the client for maintaining a programming staff just to solve an occasional problem. In computing machine services, when the problem has been programmed, both the data and program are run through the computer. The

computer then solves the problem and the answers come out printed on paper by a high-speed printer. The client is charged for the time it takes the computer to process the data. This charge is usually based on an hourly rental of the computer. If the client turns out to be a large user of computer time, rates are often figured on some other periodic basis. Most small businesses rent time on the computer by the hour. They want the benefits of fast, accurate computer solutions without the large expense of buying or renting their own computer full time.

The computer service firm does have a large overhead, which by keeping its equipment running at least two shifts a day and by spreading the fixed overhead costs over many clients is able to reduce substantially the individual job costs to the client.

The cost of using a computer service will vary from job to job and will be based on the complexity of the problem, availability of existing programs which can be used with the data pertinent to the problem at hand, and the amount of computer time necessary to solve the problem. Many large computer manufacturers have their own service subsidiaries which charge between $650 and $700 per computer hour plus about $15 per hour for programming.[18] Small, independent service firms

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[18] Smith, A. P. "Choosing A Service Bureau," Computers and Automation, 13:24, December, 1964.

which use the same types of equipment the large firms use, sell computer time for about $350 per computer hour. Programming costs average about $15 per hour, but can go down to about $8 for the programming of simpler problems.[19] Where there are existing programs which can be applied to new data, there are no programming costs and the only charge made is for computer running time.

Time-Sharing Computer System

A great deal of time and energy has gone into the design and development of time-sharing computer systems. Much of the test and evaluation work has gone on in colleges and universities. At Massachusetts Institute of Technology, a project called MAC has been carried on for about eighteen months. MAC is the acronym for the computer system, Multiple Access Computer, and for the objective, Machine Aided Cognition. This system is made up of large computers, both are IBM 7094's, with additional memory units and forty remote stations in laboratories and classrooms throughout the campus.

From these and other computer manufacturers' installations have come several satisfactory time-sharing systems which are being used today by large decentralized companies such as large banking and merchandising firms (GE, IBM, Bank of America). The system in some ways is similar to the computer service firms in that there is a centralized computer to which many people

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[19] Ibid.

or firms have access. This type of computer service could be available for the small businessman on a rental or computer-use basis.

This system is similar to the modern utility systems in that each firm would have some type of input/output device similar to a teletypewriter at the firm's office connected to a large computer.[20] The computer would have to have a large core memory to be able to store the available programs as well as the data necessary for each firm. The system would work in a sequential manner. First, the firm's problem would have to be outlined, detailed, and programmed. Then some employee of the firm would sit down at the input equipment and type out his program with the data or call for an existing program and insert the new data. This would then be transmitted to the central computer which would store all of the incoming information. The computer would then, through a sequencing device set for approximately one-twentieth of a minute of computer running time, retrieve the data and program from its memory bank or call for the program from some other type of storage (tape, disc memory, etc.) and run the calculations until the program is completed or until the time limit has stopped the program.[21] If the program has been completed, then

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[20] Fredkin, Edward. "The Time-Sharing of Computers," Computers and Automation, 12:12, November, 1963.

[21] *Ibid.*, p. 18.

the solutions from the computer will be transmitted back to the firm's input/output equipment which will print out the solution. If the program has not been completed, then the completed calculations and the rest of the program are put into the memory bank for storage until the computer runs through the other programs which have been standing by.

The costs of this type of system would vary as to the amount of computer running time necessary to solve the program and the costs of installing and rental on the input/output equipment and distribution system.

In New York City, IBM has set up a time-sharing system which will be used by clients which cover a wide variety of business and manufacturing fields. The prospectus of this project stated that the cost of this service would be approximately $10 per hour of computer time used. This system uses an IBM 7040 computer located in IBM's New York data center. The input/output equipment are consoles similar to the standard teletype machines and several Computer Aided Design machines in selected engineering and manufacturing firms.

The Small Computer

Over the past twenty years, the computer industry has grown at a phenomenal rate. With this growth, the computer has grown faster and larger. Now the trend is reversing, and much research is going into the design and production of small

computers.[22] This trend partly reflects the much-publicized miniaturization of electronic components, but also the transition of the computer industry from a pioneering status to one with a sound economic basis where profitability and low cost are most important. It also represents the transition from centralized, high priced units to decentralized computers and systems -- thus, opening a potential mass market -- small business.

There is no definite limit at present as far as the industry knows, as to how small computers will become. They are already small enough to become part of such devices as cash registers, time clocks, typewriters, and other mass-produced machines. Many in the computer industry believe that computers or components of computers will eventually be a part of so many devices that people will often be unaware of their presence. However, while there are good reasons for decreasing the dimensions of the computers, there are limits to this miniaturization. Some of these are heat dissipation, computing power, and signal-to-noise factors.[23]

Until recently, most manufactures were concerned with how fast a computer would work. The bulk of future users or the small business market could hardly care about the internal

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[22] Stiefel, Rudy. "Small Computers: A Billion Dollar Market By 1970?," Computers and Automation, 14:19, May, 1965.

[23] *Ibid.*, p. 20.

computing speeds. Most systems are expected to be limited by the speed of the input and output equipment so that the present computing speeds appear to be more than ample to cover future use requirements.

In this vein, it is interesting to draw an analogy between the automobile industry and the computer industry. Early in the century it was thought that the faster a car could go, the better it was. The later years showed, however, that high speed capability was neither significant nor did it determine who was to survive in the automobile industry and whose name would only be of antique value. More importantly, however, while top speed became relatively unimportant in the subsequent development of the auto industry, the introduction of a mass-produced car that everyone could own and operate signaled the start of one of the nation's largest industries.

Some experts believe that within ten years the sales volume of small computers will exceed that of large machines, since the market for the small data processing equipment is much larger than for the multi-million dollar machines.[24] It is felt that the key to the mass-market includes the ability of the computer to be operated directly by personnel with not more than a few hours of instruction which implies a great reduction in programming effort.

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[24] Ibid.

Another vital ingredient of the small computer for the small business must be the ability to "see what you are doing" while it is being done -- not only after it has been completed. Increased visibility or feedback of the results immediately after, and perhaps during each operation, with the opportunity to introduce choices and changes, will be vital to the non-professional user of these computers. The trend, therefore, of the computer industry will be the production of small machines which will be easier to program -- not requiring a professional or highly trained person. Such computers will be more specialized and the user will have fewer choices of programs available to him.

Many manufacturers are working on small computers for this small business market. Friden, a maker of desk calculators, has come out with an all-electronic desk model computer. IBM is attacking the problem from both ends and working toward the middle -- making their large computers smaller and their electric typewriters more intelligent, such as the IBM 632. The IBM 6400 for small business use and the IBM 1130 for engineering applications represent their efforts in the direction of penetration into the small computer market. Digital Equipment Corporation, as well as some other of the small companies -- including some foreign ones -- offer computers in the "below $5,000" range or have designs for such computers

in the making.[25]

With the purchase of one of the variety of small computers now being offered on the market, a small business can avail itself of the more modern techniques of management, production, inventory control, etc. Though the number of types of programs that can be run on the individual small computer is somewhat limited, with the proper selection of equipment the small businessman should be able to solve his problems at a relatively low capital outlay. Also, with his purchase of a small computer, the businessman has exclusive use of his own computer without the worry of a possible information "leak" to his competitors by someone or something outside of his own firm.

Comparison of Methods

Even though the cost of using a computer is probably the most important consideration for the small business, many other factors have to be considered. Are there programs available for my problems? How can I be assured that the information on future plans and developments will not get into my competitors hands? If I wish to change some of the original parameters of the problems, can I interrupt the system and make the change? How soon can I have the solution to my program after I have submitted it? These are but a few of the questions that should

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[25] *Ibid.*, p. 21.

be answered before the firm decides to use a computer. Costs will probably remain the major question for a small firm. These costs have to be broken down into two categories: the cost of acquiring time on the computer and the cost of not using the computer. The costs of acquiring time on a computer will vary as to the amount of time the firm uses the computer to run its programs and the number of hours necessary to have the problem programmed. Since there are no definite figures available for the time-sharing system's installation and rental charges, a comprehensive cost comparison of the three methods presented cannot be made. It can only be stated that the computer service firm charges only for the computer running time and the programming time, while the time-sharing system will probably have some installation and usage fee. The small computer purchase has the largest initial investment -- that being purchase and installation, plus a maintenance fee. If the firm decides to do its own programming, then the additional cost of a programmer's salary would have to be included. The cost to the firm for not using the computer could be cost of additional clerical employees, inaccurate manufacturing schedules, or loss of customers due to poor product design or pricing methods.

The computer manufacturers and some of the service bureaus have generated many programs for their large computers and have them available on tapes or in the computer's memory bank ready

for use by their clients. Programs for the small general purpose computer are limited in quantity and variety since the computer itself is still in the development stages. The time-sharing system, which has a large computer for its central operations, can use the wide variety of programs generated by the computer manufacturers.

When the firm is in a highly competitive industry or business, the need for security of the firm's information is quite important. If any of the firm's competitors had advanced knowledge of the firm's future plans and developments, they could counter any move the firm made to benefit itself from the use of these plans. In the retail business, price-cutting is quite an effective measure to defeat the competitor's sales campaign. Therefore, the most secure method would be the purchase of a small computer by a firm which has its own programmer. The least secure would be the computer service bureau in which the client is relying upon people to keep the information given them confidential. Between these two extremes is the "common carrier computer" which depends solely upon the reliability of the electronic circuitry. Both the small computer and the time-sharing method can be compromised if the firm uses outside computer programmers.

Since the firm which purchases its own small computer has exclusive use of it, the program can be interrupted, modified,

and started again without any hinderance to the system. With the use of the computer service firm, the program can only be interrupted by the computer operator at the direction of the client. With the sequencial rotation among programs in the time-sharing system, there is no opportunity for the program to be interrupted.

The time delay between submission and the solution of the problem is important to the businessman who wants to make decisions on up-to-date information. The computer service bureaus usually take at least a day to have the solution back to its client. For the time-sharing system, it's usually several hours, while for the individually owned and operated small computer, the answer may come back in a matter of minutes or seconds. The determinants of the speed of return are the workload for the computer, the length and complexity of the program, and the number of persons who have to handle the problem before, during, and after the problem is solved.

VI

CONCLUSIONS

The following conclusions based on the material presented are considered significant:

1. The computer is an unimaginative piece of electronic equipment which can act as a calculating machine, data processer, and file cabinet. It can only respond on command and has to follow a pre-determined path.

2. There is a definite place in small business for the computer to act as an aid in business decisions and analysis, and in production and design processes.

3. There is a trend in the computer industry to make the use of computers more attractive to small business. Through education and service, the industry is working on small firms to use computers in order to "streamline" their day-to-day operations and become more competitive in their markets.

4. All three of the methods presented have definite advantages and disadvantages. If a small business is investigating the feasibility of using a computer in the firm's operations, the choice of which method to choose should be based on some idea of the amount of time the computer would be used, the type of problems calculated by the firm, and the financial position of the firm.

The purchase or use of a computer just for the sake of saying, "I'm using a computer in my business," is a foolhardy action for any business to take. The true worth of the computer for small business is in the speed with which a computer can solve lengthy and very complex problems. As a small aircraft part manufacturer who had used a computer for the first time to assist in engineering his product concluded:

> From now on, in research, product development, and marketing -- all the way from deep freezers to atomic engines -- the small company can hope for the first time to make a definite contribution.[26]

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[26] Seligsohn, _op_. _cit_.

VII

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APPENDIX I

Comparison In Detail of Simon's Decision Hierarchy*

TYPES OF DECISIONS	DECISION-MAKING TECHNIQUES	
	Traditional	Modern
Programmed: Routine, repetitive decisions Organization develops specific processes for handling them	1. Habit 2. Clerical routine: Standard operating procedures 3. Organization structure: Common expectations A system of subgoals Well-defined informational channels	1. Operations Research: Mathematical analysis Models Computer simulation 2. Electronic data processing
Nonprogrammed: One-shot, ill-structured novel, policy decisions Handled by general problem-solving processes	1. Judgment, intuition, and creativity 2. Rules of thumb 3. Selection and training of executives	Heuristic problem-solving techniques applied to: (a) training human decision makers (b) constructing heuristic computer programs

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*Simon, Herbert. The New Science of Management Decision. New York: Harper and Row, 1960, p. 8.

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